May 18, 2001

Mr. Mark E. Warner
Vice President, TMI Unit 1
AmerGen Energy Company, LLC
P.O. Box 480
Middletown, PA 17057

SUBJECT: THREE MILE ISLAND NUCLEAR STATION, UNIT 1 (TMI-1) - RE: PROPOSED IRRADIATION OF FUEL RODS BEYOND CURRENT LEAD ROD BURNUP LIMIT (TAC NO. MB1013)

Dear Mr. Warner:

By letter dated January 18, 2001, as supplemented by letter dated April 11, 2001, you requested Nuclear Regulatory Commission (NRC) approval to operate in excess of the previously approved burnup limits for four fuel rods. You stated that you plan to irradiate these rods to average burnups ranging from 63 to 69 GWd/mtU (giga-watt days per metric ton of uranium). These rods are currently in their third cycle of irradiation and will have cumulative rod average burnups of 42 to 48 GWd/mtU. The fuel rods will replace some of the original fuel rods in a twice-burned fuel assembly which will then be irradiated for one additional cycle at TMI-1, during Cycle 14, which is scheduled to begin in October 2001. NRC approval is requested because the rods will operate in excess of lead rod burnup limits currently identified for Framatome Cogema Fuels (FGF) Mark-B fuel as specified in NRC-approved FCF Topical Reports, BAW-10186P-A, "Extended Burnup Evaluation," June 1998, and BAW-10227P-A, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR [pressurized-water reactor] Reactor Fuel," February 2000. You stated that your request is similar to a request approved for North Anna Units 1 and 2 by letter dated September 8, 1999.

The NRC staff has reviewed your request and has no objection to it. The proposed irradiation of four fuel rods to average burnups ranging from 63 to 69 GWd/mtU is in agreement with guidelines currently being developed for lead test assemblies, and the data obtained will provide useful information to the NRC staff and the industry. Details of the NRC staff's review are contained in the attached safety evaluation. The NRC staff wishes to note that the quality of your submittals was excellent.

Sincerely,

/RA/

Timothy G. Colburn, Senior Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-289

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

AMERGEN ENERGY COMPANY, LLC

THREE MILE ISLAND NUCLEAR STATION, UNIT 1

DOCKET NO. 50-289

1.0 INTRODUCTION

By letter dated January 18, 2001, AmerGen Energy Company, LLC (AmerGen), informed the Nuclear Regulatory Commission (NRC) that Three Mile Island Nuclear Station, Unit 1 (TMI-1), plans to irradiate four M5 clad fuel rods to end-of-life rod average burnups ranging from about 63 to 69 GWd/mtU (giga-watt days per metric ton of uranium). A conference call to discuss the details of the licensee's submittal was held on April 6, 2001, between the NRC staff and AmerGen. Additional information was provided by letter dated April 11, 2001. Irradiation of these rods in fuel assembly, designated NJ07U9, will provide data on fuel and materials performance that will support industry goals of extending the current fuel burnup limits and will provide data to address NRC questions related to fuel performance behavior at high burnups. The data will also help confirm the applicability of nuclear design and fuel performance models at high burnups.

2.0 BACKGROUND

The fuel rods to be used in this program were originally fabricated by Framatome Cogema Fuels (now Framatome ANP, Inc. (Framatome)) as part of a demonstration assembly that was irradiated in TMI-1. These M5 clad fuel rods are in their third cycle of irradiation, and will have cumulative rod average burnups ranging from approximately 42 to 48 GWd/mtU at the end of the current operating cycle. The M5 fuel rods will replace some of the original fuel rods in a twice-burned Framatome fuel assembly (host assembly NJO7U9), which will then be irradiated for one additional cycle in TMI Unit 1. The end-of-cycle rod average burnups of the four M5 fuel rods are expected to range from about 63 to 69 GWd/mtU, while the remainder of the fuel in the host assembly will achieve a burnup of approximately 55 GWd/mtU (assembly average burnup).

Fuel rods with Framatome's advanced cladding material, M5, were first irradiated in TMI-1 in 1995 in two demonstration assemblies (assemblies NJO7VX and NJO7VY). These demonstration fuel assemblies have Zircaloy-4 skeletons and most of the fuel rods are standard fuel rods with Zircaloy-4 cladding, but a limited number of rods in each assembly were made with the advanced cladding material. Both of these assemblies will have been irradiated for three cycles (at the end of TMI-1 Cycle 13), and will have achieved an assembly average burnup of about 45 GWd/mtU. The four M5 lead test rods for this program will be from either

fuel assembly NJ07VX or NJ07VY. Irradiation of a small number of fuel rods in this manner will generate fuel performance data at high burnups with minimal impact on core operation. Since the submittal was prepared before the reload design process was completed, it indicated that the fuel assembly would be fully evaluated and that it was expected that all design criteria would be met. Furthermore, the submittal stated, "If for any reason the cycle-specific calculations do not confirm the acceptability of irradiating the four fuel rods for a fourth cycle to a higher burnup, or if an unreviewed safety question is created, the high burnup rods will not be reconstituted into assembly NJO7U9. Assembly NJO7U9 would then be irradiated in the Cycle 14 core as a standard reload fuel assembly with no fuel rods exceeding 62 GWd/mtU." This statement was reiterated in the teleconference on April 6, 2001. In the April 11, 2001, submittal the licensee stated, "Subsequent to the TMI-1 14R refueling outage fuel assembly Post Irradiation Examinations (PIE), AmerGen will provide NRC the results of the PIE data obtained for the M5 lead test rods. At that time AmerGen will also provide to NRC confirmation of the results of the TMI-1 Cycle 14 specific fuel rod design analysis for the M5 lead test rods performed to determine acceptability for use in Cycle 14. If fuel rod behavior as observed in the PIE is not as expected or if analysis does not confirm fuel rod design criteria are met, then the M5 lead test rods will not be used in Cycle 14. AmerGen will also provide NRC the data obtained from PIE performed on the M5 lead test rods at the conclusion of TMI-1 operating Cycle 14."

The proposed irradiation of these fuel rods does not require any change to the technical specifications. However, since the high burnup fuel rods are planned to operate to burnup levels exceeding the rod burnup limit of 62 GWd/mtU, NRC approval was requested prior to implementation of the program because the rods will operate in excess of lead rod burnup limits currently identified for Framatome Cogema Fuels (FCF) Mark-B fuel as specified in NRC-approved FCF Topical Reports, BAW-10186P-A, "Extended Burnup Evaluation," June 1998, and BAW-10227P-A, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR [pressurized-water reactor] Reactor Fuel," February 2000.

3.0 EVALUATION

The NRC has recently been working with the industry to develop guidelines for lead test assemblies (LTAs) including fuel assemblies such as the one under review. The intention is to develop a set of guidelines which provides a structured process for LTAs while maintaining safety. These guidelines will be consistent with the NRC performance goals which are: maintain safety, maintain public confidence, improve efficiency and effectiveness of regulation and reduce unnecessary regulatory burden. Many different aspects will be addressed in LTA guidelines, including: characterization of the fuel assembly both pre- and post-irradiation, for which pool-side examinations will be performed, the number of LTAs allowed in any given core, the location or placement of LTAs within the core, what the safety analysis should cover and reporting requirements. The evaluation of the request to irradiate the four M5 rods has been done with these developing guidelines in mind.

3.1 Pre- and Post-Irradiation Characterization of the Fuel Assembly

The M5 demonstration at TMI-1 is important because TMI-1 operates with an aggressive environment which includes 24-month cycles and a high lithium reactor coolant system concentration. The first cycle burnup for fuel assemblies NJ07VX and NJ07VY was low (13

GWd/mtU). At the end of the second cycle, the assemblies achieved an average burnup of 38.5 GWd/MtU. Post-irradiation examinations (PIE) after the second cycle showed good results.

The average M5 oxide thickness was approximately 12 microns. The maximum measured oxide was 21 microns and the average maximum was 15 microns. By comparison, six Zircaloy-4 rods immediately adjacent to the M5 rods examined had an average oxide thickness of approximately 27 microns. The maximum measured oxide was 57 microns and the average maximum was 32 microns. In addition, the M5 fuel rods showed improved performance with respect to fuel rod growth as expected.

At the completion of the current cycle, the M5 lead test rods will be examined and the rods will be reconstituted into host assembly NJ07U9. These rods will again be examined after their fourth cycle of operation. Visual examinations, cladding oxide measurements, rod growth measurements and rod diameter measurements will be made during both PIEs. As stated in the letter dated April 11, 2001, the licensee has committed to provide the results of the examinations to the NRC following each PIE.

The results from the PIE after the current cycle will confirm that the M5 rod performance was as predicted and that irradiation for an additional cycle should not result in any unusual behavior. If the results are not as expected, the M5 rods will not be used.

Post-irradiation testing of LTAs is essential to the value of the program. The licensee has proposed an inspection program that the NRC staff considers to be acceptable. The NRC staff considers the test program to be appropriate and AmerGen has committed to send the results to the NRC after completion of the program.

3.2 Design Evaluation

A preliminary evaluation of irradiating the four M5 rods in TMI-1 Cycle 14 showed that all design criteria are expected to be satisfied and that no unreviewed safety questions would result. The fuel vendor will perform the fuel rod design analysis for the entire core including the demonstration assembly. The analysis of assembly NJ07U9 will be evaluated separately to ensure that all fuel rod design criteria that are applicable for the current lead rod burnup of 62 GWd/mtU are also satisfied for the high burnup M5 rods.

Host assembly NJ07U9 will be loaded into the center of the core in Cycle 14 and will operate at an assembly average power near the core average power throughout the cycle. The M5 lead test rods will not be in the highest fuel rod power density locations and will not be limiting with respect to any safety analysis limit. The neutronic effects of the M5 lead test rods have already been evaluated using the NRC-approved CASMO3 code. The M5 lead test rods had a higher initial enrichment than the fuel rods that they are replacing; but, since their burnup was larger, the net result was a small decrease in reactivity and power production for each lead test rod location when compared with that for host assembly NJ07U9 with the original rods. For the reload power distribution analysis and fuel rod performance analysis, the host assembly will be modeled to determine the power peaking for each of the four M5 lead test rods.

Framatome will assess the fuel rod design criteria for all rods in host assembly NJ07U9 using the NRC-approved models and methods. The TACO3 code will be used to demonstrate acceptable fuel thermal and fuel mechanical performance. Cladding corrosion and fuel rod growth would normally be the limiting criteria for high burnup rods such as the M5 lead test rods. However, based on the performance of M5 thus far, the limiting parameter will be rod internal pressure. The design analysis will verify that the rod internal pressure criterion is met.

Fuel assembly and core component pressure drops are not affected by the small number of high burnup rods. The thermal hydraulic performance of fuel assembly NJ07U9 will be performed in accordance with the normal reload design methodology using NRC-approved codes and methods. The fuel assembly will be required to met the same design criteria as other fuel assemblies in the core.

3.3 Safety Assessment

Even though the M5 lead test rods and host assembly NJ07U9 will not lead the core with respect to core operating limits, an evaluation of all safety analyses is being performed to verify that the analyses of record will not be invalidated. The results of the loss-of-coolant accident (LOCA) analyses evaluation showed that the current LOCA analyses for TMI-1 will be valid as long as fuel assembly NJ07U9 is not placed in a high-power location and the rod internal pressure criterion is met. The licensee has stated that the M5 lead test rods will not be used if these conditions are not met. Thus, the current LOCA analyses for TMI-1 will be valid.

The limiting transients at end-of-life (EOL) conditions, when the M5 lead test rods will be above the approved 62 GWd/mtU limit, are the main steamline break (MSLB) and the control rod ejection accidents. The important parameter for the MSLB is the moderator temperature coefficient (MTC). Since, replacing four rods will have a negligible effect on the MTC, no additional consideration beyond that normally performed for TMI-1 Cycle 14 will be needed for the MSLB. For the control rod ejection accident, the main issues are fuel melt, departure from nucleate boiling and offsite dose consequences. Since the host assembly will not be in a high-power core location and the four lead test rods will be operating at lower powers than the rods that they replace, use of the four M5 lead test rods will not have a significant effect.

4.0 CONCLUSION

Based on the above evaluation, the NRC staff agrees that it is acceptable for TMI-1 to include irradiation of fuel assembly NJ07U9 with the four M5 lead test rods that will attain EOL rod average burnups ranging from about 63 to 69 GWd/mtU.

Principal Contributor: M. Chatterton

Date: May 18, 2001

Three Mile Island Nuclear Station, Unit No. 1

cc:
George H. Gellrich
Plant Manager
AmerGen Energy Company, LLC
P. O. Box 480
Middletown, PA 17057

James A. Hutton
Director - Licensing
PECO Energy Company
Nuclear Group Headquarters
Correspondence Control Desk
P.O. Box 195
Wayne, PA 19087-0195

Edwin C. Fuhrer
Manager - Regulatory Engineering
AmerGen Energy Company, LLC
P.O. Box 480
Middletown, PA 17057

Edward J. Cullen, Jr., Esquire
PECO Energy Company
2301 Market Street (S23-1)
Philadelphia, PA 19103

Jeffrey A. Benjamin
Licensing - Vice President
Exelon Corporation
1400 Opus Place, Suite 900
Downer's Grove, IL 60521

Chairman
Board of County Commissioners
of Dauphin County
Dauphin County Courthouse
Harrisburg, PA 17120

Chairman
Board of Supervisors
of Londonderry Township
R.D. #1, Geyers Church Road
Middletown, PA 17057

Senior Resident Inspector (TMI-1)
U.S. Nuclear Regulatory Commission
P.O. Box 219
Middletown, PA 17057

Regional Administrator
Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Michael A. Schoppman
Framatome ANP
Suite 705
1911 North Ft. Myer Drive
Rosslyn, VA 22209

David J. Allard, Director
Bureau of Radiation Protection
Pennsylvania Department of
Environmental Resources
P.O. Box 2063
Harrisburg, PA 17120

Dr. Judith Johnsrud
National Energy Committee
Sierra Club
433 Orlando Avenue
State College, PA 16803

John F. Rogge, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Eric Epstein
TMI Alert
4100 Hillsdale Road
Harrisburg, PA 17112